Research Report
KTC-89-3

EVALUATION OF CONSTRUCTION-ZONE PAVEMENT MARKING MATERIALS

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16. Abstract

The objectives of this study were to evaluate available foil-back and removable tapes as well as one new construction-zone raised pavement marker and to recommend materials that should be included on approved lists for use by the Kentucky Department of Highways. Tapes were placed on transverse test sections and the reflectivity, durability, and appearance were observed.

Tapes to be included on the approved lists for foil-back and removable tapes were recommended. Tapes manufactured by 3M, Flex-O-Lite, and Swarolite were included on the list of acceptable foil-back tapes. Recommended removable tapes were the 3M and Cataphote removable tapes. The Astro Optics construction-zone marker was added to the approved list for construction-zone raised pavement markers. Data were presented for various permanent tapes to aid in the selection of this material.

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INTRODUCTION

Pavement marking is a vital component of traffic control during construction and maintenance activities. An alternative to typical paint striping is the use of preformed tapes or construction-zone raised pavement markers. When the stripe must be removed, removable tape or markers provide an advantage over traffic paint.

Objectives of this study were to evaluate available foil-back and removable preformed tapes as well as one new construction zone raised pavement marker and to recommend materials that should be included on approved lists maintained by the Kentucky Transportation Cabinet. Similar studies were completed in 1985 (1) and 1987 (2). In addition, permanent preformed tapes were evaluated as part of this study.

PROCEDURE

PREFORMED TAPE

Transverse test sections of the tapes were placed on US 421 (ADT of 11,000) in Frankfort on May 25, 1988, on both bituminous and portland cement concrete surfaces. The tape was placed across the shoulder lane. Three white and three yellow stripes were placed on both the bituminous and concrete pavements, so 12 stripes of each material were placed. Each stripe was approximately 11 feet in length.

The reflectivity, durability, and appearance of the tapes were observed periodically at a test location. Reflectivities of the tapes were rated using a portable retroreflectometer (PRR). The Mirolux 12 PRR was used to collect reflectivity data. The PRR provided data in terms of millicandelas per square foot per footcandle (will be referred to as millicandelas). The durability and appearance of the tapes also were observed during each visit and were rated after six months in service. Also, the removability of the removable tape was tested during each visit. A minimum of six months of data was collected for all tapes. The tapes from one manufacturer were placed about two months after the other tapes such that eight months of data were collected for most tapes. Ten sets of data were collected over the test period.

An effort was made to contact all manufacturers of construction-zone and permanent preformed tape. Samples from 3M, Flex-O-Lite, Swarolite, Linear Dynamics, Cataphote, P. B. Laminations, Seibulite, and Volare were received and evaluated.

CONSTRUCTION ZONE MARKERS

The reflectivity, durability, and appearance of the available construction zone markers were evaluated in a previous report (2). Samples from Stimsonite, 3M, Flex-O-Lite, Swarolite, and Davidson Plastics were received and evaluated. The Stimsonite 66 and Flex-O-Lite construction-zone markers were recommended to be placed on the approved list. Since that report, a construction-zone marker manufactured by Astro Optics has been submitted for approval. A total of 68 white markers were placed on the lane line and 85 yellow markers on the edge line of the Bluegrass Parkway (ADT of 8,000). The reflectivity, durability, and appearance of this marker was evaluated over an eight-month period.

RESULTS

PREFORMED TAPE

Reflectivity

Summaries of the PRR measurements for the foil-back, removable, and permanent tapes at the transverse-stripe test location are shown in Tables 1, 2, and 3, respectively. Measurements indicated that all tapes sustained a significant loss in reflectivity over the evaluation period. However, some tapes lost reflectivity more rapidly than others. Reflectivity data were collected in the right wheel path. The reflectivity data are also presented in graphical form in Figures 1 through 6. A minimum reflectivity level of 70 millicandles was recommended in the previous report (2). This would be considered an absolute minimum with a more desirable minimum level of 100 millicandles.

Considering both white and yellow foil-back tapes (Table 1 and Figures 1 and 2), the 3M construction grade tape maintained reflectivity better than any other tape. The P. B. Laminations tapes, followed by the Swarolite Construction Grade tape, lost reflectivity sooner than the other tapes. The Swarolite Engineering and Flex-O-Lite Wet-Reflective tapes initially had substantially higher reflectivity readings, but within two months the reflectivities of the other tapes were similar.

PRR measurements of the removable tapes (Table 2 and Figures 3 and 4) show that the Cataphote tape maintained the highest reflectivity for the white tapes. No sample of yellow tape was provided for the Cataphote removable tape. The P. B. Laminations tape, followed by the Seibulite tape, sustained the earliest loss of reflectivity.

PRR measurements of the permanent tapes (Table 3 and Figures 5 and 6) show that the 3M Series 320 (bisymmetric tape) maintained the highest reflectivity for both the white and yellow tapes. The Seibulite, Volare, and Linear Dynamics tapes sustained the greatest loss in reflectivity. The 3M Series 350 tape was the second best tape in terms of maintaining reflectivity, followed by the Cataphote Catatile tape.

Durability and Appearance

During each inspection, the durability and appearance of the tapes were noted. However, only during the six-month evaluation was a number assigned. The appearance and durability were rated using guidelines given in ASTM 713. The durability rating is based on a scale of 0 through 10 and is equal to one-tenth of the material remaining on the pavement in the wheel path area. Appearance is the impression of the material from a distance of at least 10 feet. It includes a comparison of the color compared with the original color. The tapes were rated from a low of 0 to a maximum of 10.

The durability ratings after six months in service are given in Table 4. The ratings show that none of the tapes experienced a problem with durability. The foil-back tapes generally had ratings of from 9.0 to 9.5 with the lowest rating of 8.5 for Cataphote Catatape. Almost all the removable and permanent tapes had ratings of 10. The exceptions were the removable Seibulite and 3M Series 320 tapes that had ratings of 9.5.

The appearance ratings after six months in service are given in Table 5. The ratings of the foil-back tapes were similar with a slightly lower rating for the 3M tape. The ratings for the removable tapes were also similar with a slightly higher rating for the 3M Removable tape. There was more variation with the appearance ratings of the permanent tape. The permanent tapes generally had higher ratings than the foil-back or removable tapes. The highest overall ratings were for the Cataphote Catatile and 3M Series 5730 tapes with the lowest ratings for the 3M Series 320 tape which had substantially lower ratings than the other permanent tapes.

Removability

The ease of removal for the five removable tapes was investigated along with the length of time necessary for the stain or mark left after removing the tapes to disappear. One stripe of each tape was removed during each inspection. All removable tapes were removed fairly easily at first. The first noticeable problem with removal was with the Seibulite tape. The tape came up in small pieces and was hard to remove in the wheel path area. The Linear Dynamics tape later experienced similar problems. By the end of the evaluation period, the Seibulite and Linear Dynamics tapes could not be removed in the wheel paths. The 3M, Cataphote, and P. B. Laminations tapes could still be removed fairly easily at the end of the evaluation period.

The adhesive marks remaining on the pavement after removal of the tapes remained after two months but disappeared after three months. The least noticeable adhesive marks came from the 3M tape and the most came from the Seibulite tape.

CONSTRUCTION-ZONE MARKERS

The previous study evaluated Stimsonite 66, Davidson, Flex-O-Lite, Swarolite, and 3M markers and recommended that Stimsonite and Flex-O-Lite be placed on the approved list (2). A marker manufactured by Astro Optics was later introducted and was tested in this study.

A total of 68 white and 85 yellow markers was placed on June 3, 1988 on the Bluegrass Parkway. This road is a four-lane, divided highway with an ADT of approximately 8,000. The white markers were placed along the lane line while the yellow markers were placed along the yellow edge line. After six months in service, none of the markers was missing. Also, none of the lens in the yellow markers was damaged. Of the 68 white markers, 11 (6.8 percent) had damage to the lens. A nighttime inspection revealed that the reflectivity was maintained over the six-month period. The yellow markers were placed at both 5-foot and 10-foot intervals. The markers placed at the 5-foot interval adequately represented a solid line.

SUMMARY AND CONCLUSIONS

FOIL-BACK TAPE

The reflectivity, durability, and appearance evaluations revealed a range in performance of the tapes, especially in the area of reflectivity. The 3M tape maintained the highest reflectivity with the Cataphote, Swarolite Construction, and P. B. Lamination tapes sustaining unacceptable losses in reflectivity in either the white or yellow tape. The Cataphote tape

experienced slightly more wear than the other tapes. The appearance of the 3M tape was not maintained as well as the other tapes.

REMOVABLE TAPE

The evaluations resulted in the finding that not all of the tested tapes could be recommended. The 3M and Cataphote tapes met the requirements of the tests. The Cataphote white tape maintained the highest reflectivity (no yellow Cataphote removable tape was placed). The Seibulite and P. B. Laminations tapes did not maintain acceptable reflectivity levels. Neither the Seibulite nor Linear Dynamics tapes met the removability requirement in that they were very difficult to remove and could not be removed in the wheel path after several months in service.

PERMAMENT TAPE

The permanent tapes should be evaluated for a longer time period to establish recommendations. After the evaluation period of this test, all of the tapes remained acceptable in the areas of durability and appearance. The appearance of the 3M Series 320 tape was not maintained as well as the other tapes. The reflectivity measurements varied substantially. The reflectivity of the Seibulite, Volare, and Linear Dynamics tapes dropped below the absolute minimum of 70 millicandelas (2). The highest reflectivity measurements were for the 3M Series 320 tape followed by the 3M Series 350 tape.

CONSTRUCTION-ZONE MARKERS

The only new marker tested was one manufactured by Astro Optics. This marker met the requirements for construction-zone markers (2).

IMPLEMENTATION

The following tapes are recommended to be included on the approved list for foil-back construction tape:

1. 3M Construction Grade (5160 and 5161),
2. Flex-O-Lite Wet-Reflective and Construction Grade, and
3. Swarolite Engineering Grade.

The following tapes are recommended to be included on the approved list for removable tapes:

1. 3M Removable (5710 and 5711) and
2. Cataphote Removable.

The Astro Optics construction-zone marker is recommended to be added to the approved list of construction-zone markers.

The permanent tapes should be monitored for a longer time period. However, this data can be used to aid in the selection of acceptable materials.

REFERENCES

1. Agent, K. R. and Pigman, J. G.; "Evaluation of Construction Zone Pavement Marking Materials," University of Kentucky Transportation Research Program, Report UPTRP-85-24, September 1985.

2. Agent, K. R. and Pigman, J. G.; "Evaluation of Construction Zone Pavement Marking Materials," University of Kentucky Transportation Research Program, Report UKTRP-87-11, May 1987.

TABLE 1. PRR MEASUREMENTS FOR FOIL-BACK TAPE

COLOR	MANUFACTURER AND BRAND	PRR MEASUREMENT* MONTHS IN SERVICE NEW	0.5	1	2	3	4	5	6	7	8
White	3M Construction (5160)	720	550	550	490	410	340	340	300	250	210
	Flex-O-Lite Wet Reflective	1,100	770	780	480	350	170	130	100	80	80
	Flex-O-Lite Construction	740	550	530	400	360	200	180	140	110	90
	Swarolite Engineering	1,190	920	880	550	380	220	180	130	110	90
	Swarolite Construction	970	780	750	350	150	90	80	80	70	70
	Catephote (Catatape)	870	730	660	410	320	220	180	120	90	80
	P B Laminations (Aztec)	410		140	80	80	90	70	80		
Yellow	3M Construction (5161)	530	400	390	350	290	230	200	190	160	140
	Flex-O-Lite Wet Reflective	1,100	810	810	460	320	200	160	140	100	90
	Flex-O-Lite Construction	740	470	490	400	300	200	180	140	100	90
	Swarolite Engineering	1,030	810	770	550	390	240	200	170	110	100
	Swarolite Construction	620	450	400	390	310	230	210	160	110	90
	Cataphote (Catatape)	520	390	340	190	140	100	90	80	60	60
	P B Laminations (Aztec)	400		190	120	100	100	70	80		

* Millicandelas per square foot per footcandle.

TABLE 2. PRR MEASUREMENTS FOR REMOVABLE TAPE

COLOR	MANUFACTURER AND BRAND	PRR MEASUREMENT* MONTHS IN SERVICE									
		NEW	0.5	1	2	3	4	5	6	7	8
White	3M Removable (5710)	530	520	490	400	290	190	180	120	100	100
	Seibulite (5804)	530	490	430	290	230	150	130	110	90	90
	Cataphote	690	600	600	540	530	420	430	360	250	190
	Linear Dynamics	650	620	600	480	400	290	240	220	150	130
	P B Laminations (Aztec)	250		190	130	120	110	90	90		
Yellow	3M Removable (5711)	530	470	450	410	320	230	210	160	110	100
	Seibulite (5812)	290	180	160	110	80	60	60	60	40	50
	Linear Dynamics	520	480	410	390	250	190	160	150	110	90
	P B Laminations (Aztec)	140		110	110	110	100	80	80		

* Millicandelas per square foot per footcandle.

TABLE 3. PRR MEASUREMENTS FOR PERMANENT TAPE

COLOR	MANUFACTURER AND BRAND	PRR MEASUREMENT* MONTHS IN SERVICE									
		NEW	0.5	1	2	3	4	5	6	7	8
White	Cataphote (Catatile)	300	310	290	280	270	220	210	180	150	130
	3M (5730)	350	380	350	340	280	200	160	130	90	90
	3M (350)	380	350	350	350	300	260	250	230	190	190
	3M (320)	600	510	530	470	440	420	370	330	260	250
	Linear Dynamics	590	390	330	200	140	120	110	120	90	100
	Volare (Director)	250	210	200	180	150	130	120	120	90	90
	Seibulite (5004)	400	270	260	150	120	110	110	120	90	110
Yellow	Cataphote (Catatile)	290	370	360	350	290	270	240	210	160	150
	3M (5730)	370	300	290	270	210	170	140	150	90	90
	3M (350)	350	310	310	320	230	240	220	230	180	180
	3M (320)	750	550	560	500	440	380	340	340	270	240
	Linear Dynamics	410	250	250	160	100	80	70	80	60	60
	Volare (Director)	140	130	110	90	70	70	60	70	50	50
	Seibulite (5012)	160	130	110	80	60	50	50	60	30	50

* Millicandelas per square foot per footcandle.

TABLE 4. DURABILITY RATINGS AFTER SIX MONTHS IN SERVICE

TYPE OF TAPE	MANUFACTURER AND BRAND	DURABILITY RATING			
		BITUMINOUS		PCC	
		WHITE	YELLOW	WHITE	YELLOW
Foil-Back	3M Engineering	9.5	9.5	9.5	9.0
	Flex-O-Lite Wet Reflective	9.5	9.5	9.5	9.0
	Flex-O-Lite Construction	9.0	9.0	9.5	9.0
	Swarolite Engineering	9.5	9.5	9.5	9.0
	Swarolite Construction	9.5	9.5	9.5	9.0
	Cataphote (Catatape)	9.0	9.0	8.5	8.5
	PB Laminations (Aztec)	9.0	9.0	9.0	9.0
Removable	3M	10.0	10.0	10.0	10.0
	Seibulite	9.5	9.5	10.0	10.0
	Cataphote	10.0	*	10.0	*
	Linear Dynamics	10.0	10.0	10.0	10.0
	PB Laminations (Aztec)	10.0	10.0	10.0	10.0
Permanent	Catephote (Catatile)	10.0	10.0	10.0	10.0
	3M (5730)	10.0	10.0	10.0	10.0
	3M (350)	10.0	10.0	10.0	10.0
	3M (320)	10.0	9.5	9.5	9.5
	Linear Dymanics	10.0	10.0	10.0	10.0
	Volare (Director)	10.0	10.0	10.0	10.0
	Seibulite	10.0	10.0	10.0	10.0

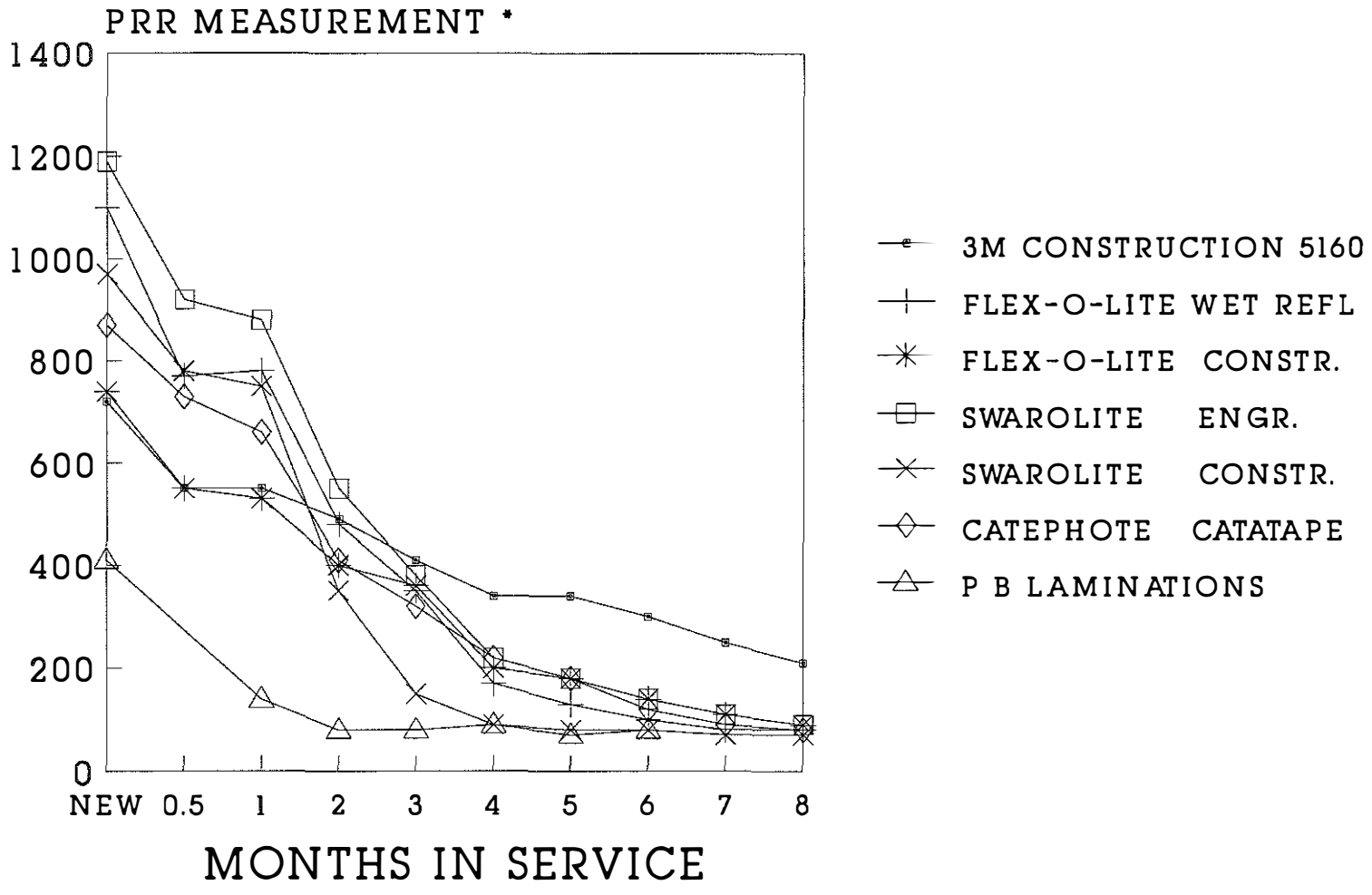
* No tape installed.

TABLE 5. APPEARANCE RATINGS AFTER SIX MONTHS IN SERVICE

TYPE OF TAPE	MANUFACTURER AND BRAND	APPEARANCE RATING			
		BITUMINOUS		PCC	
		WHITE	YELLOW	WHITE	YELLOW
Foil-Back	3M Engineering	4.5	4.5	4.0	4.5
	Flex-O-Lite Wet Reflective	5.5	5.0	5.0	5.5
	Flex-O-Lite Construction	5.5	5.0	5.0	5.5
	Swarolite Engineering	5.5	5.0	5.5	5.5
	Swarolite Construction	5.5	5.0	5.5	5.0
	Cataphote (Catatape)	5.0	4.5	5.0	5.0
	PB Laminations (Aztec)	5.5	5.0	5.5	5.5
Removable	3M	7.0	7.0	6.5	6.5
	Seibulite	6.0	5.5	5.0	5.5
	Cataphote	6.0	*	5.5	*
	Linear Dynamics	6.0	6.0	5.5	5.5
	PB Laminations (Aztec)	6.0	6.0	5.5	5.5
Permanent	Catephote (Catatile)	8.0	6.5	7.0	7.0
	3M (5730)	8.0	8.0	7.0	7.5
	3M (350)	6.5	7.0	5.0	6.0
	3M (320)	4.5	4.0	4.0	4.5
	Linear Dymanics	6.0	7.0	5.5	6.0
	Volare (Director)	7.5	8.0	5.0	6.0
	Seibulite	5.5	6.0	5.5	5.5

* No tape installed.

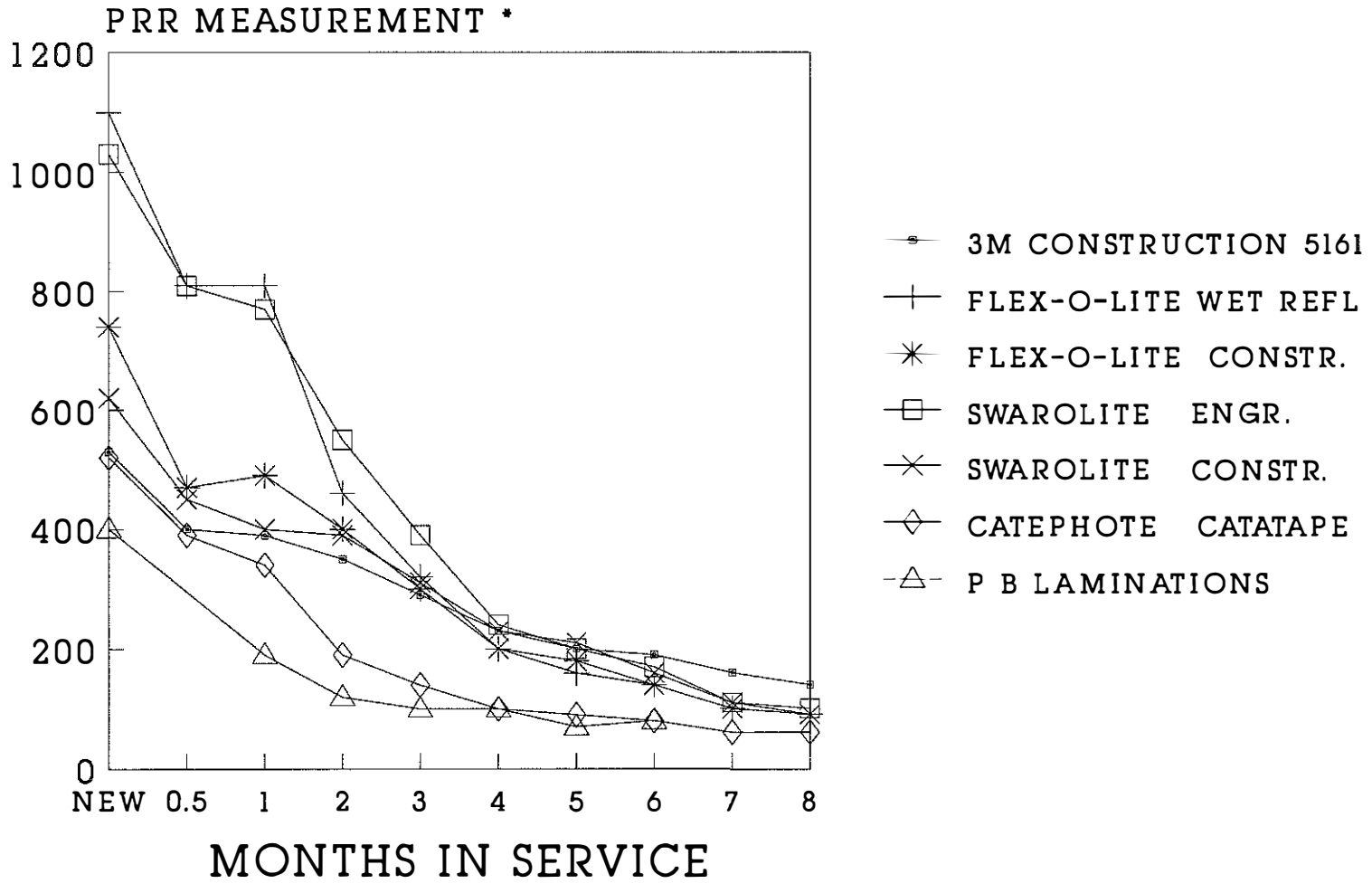
PRR MEASUREMENTS FOR FOIL-BACK TAPE
WHITE



* Millicandelas/square foot/footcandles

Figure 1. PRR Measurements for White Foil-Back Tape.

PRR MEASUREMENTS FOR FOIL-BACK TAPE
YELLOW



* Millicandelas/square foot/footcandles

Figure 2. PRR Measurements for Yellow Foil-Back Tape.

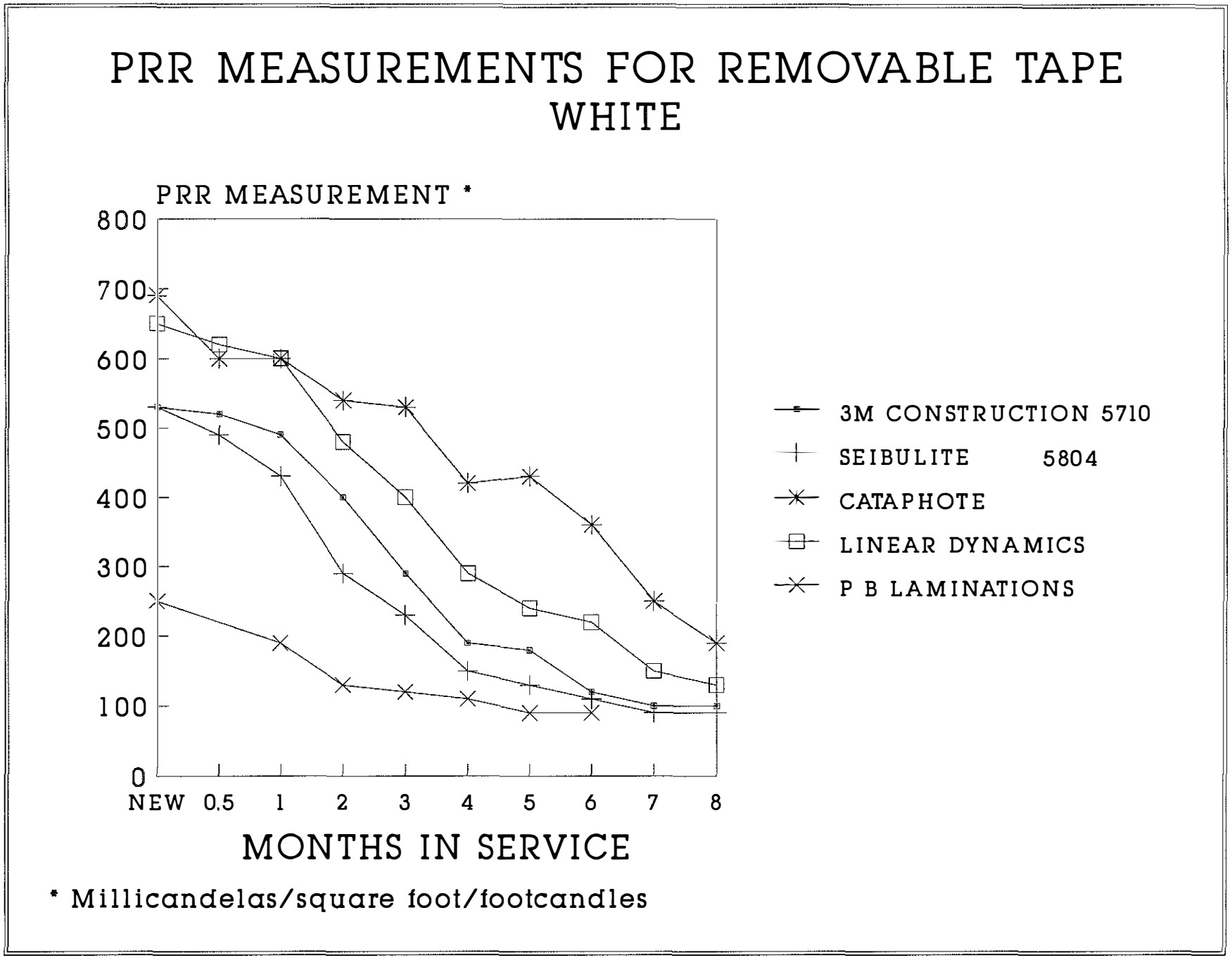
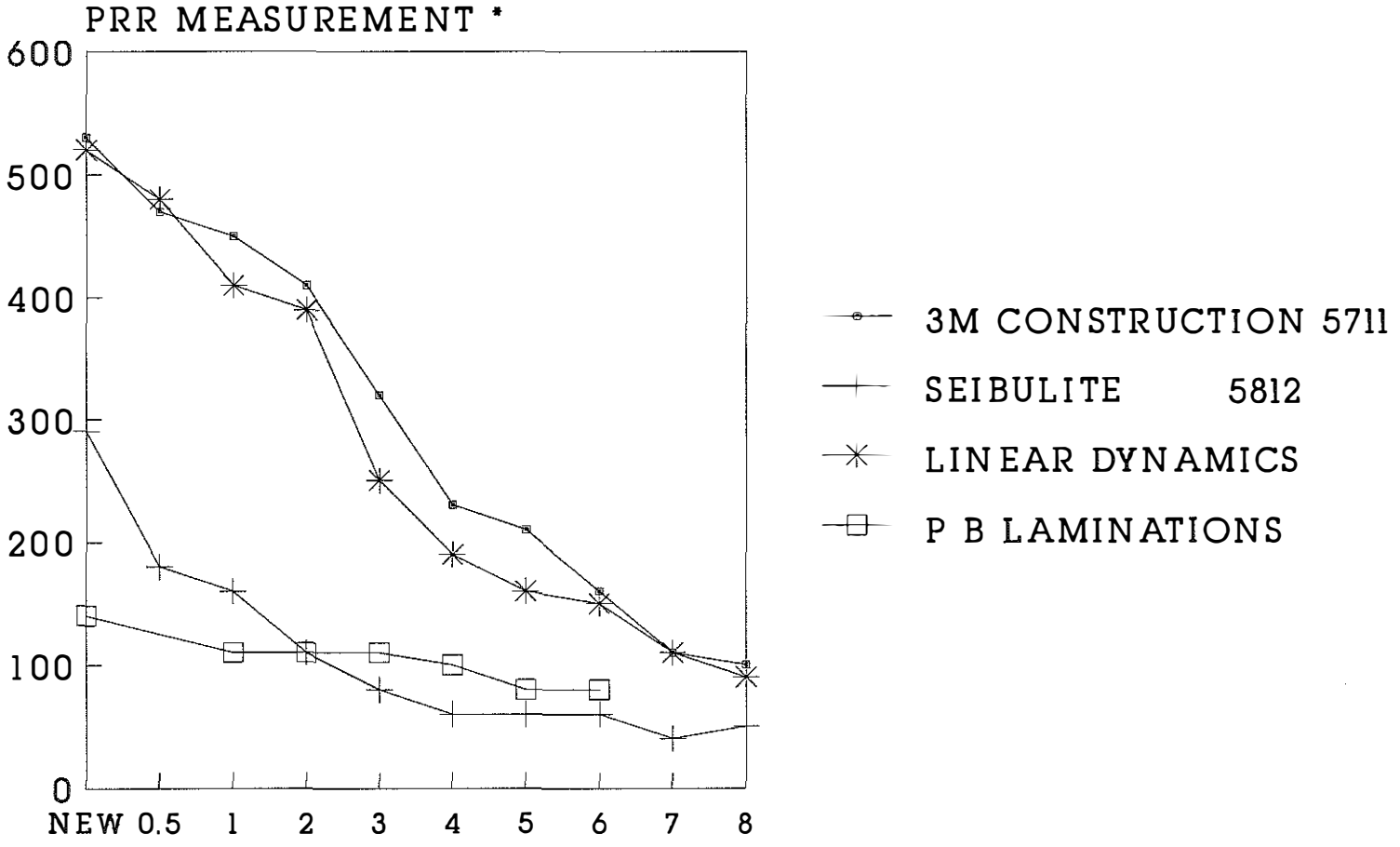


Figure 3. PRR Measurements for White Removable Tape.

PRR MEASUREMENTS FOR REMOVABLE TAPE
YELLOW



* Millicandelas/square foot/footcandles

Figure 4. PRR Measurements for Yellow Removable Tape.

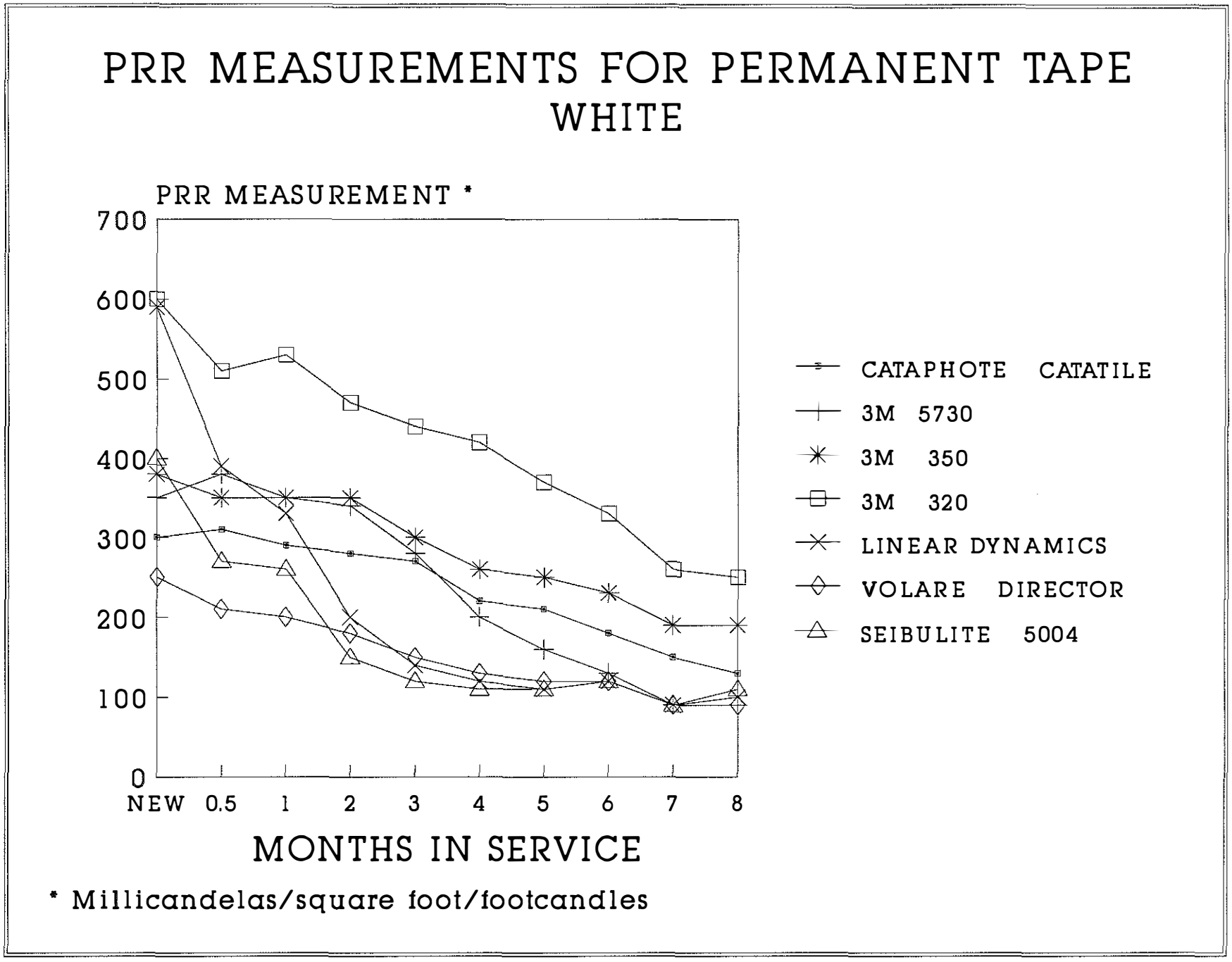
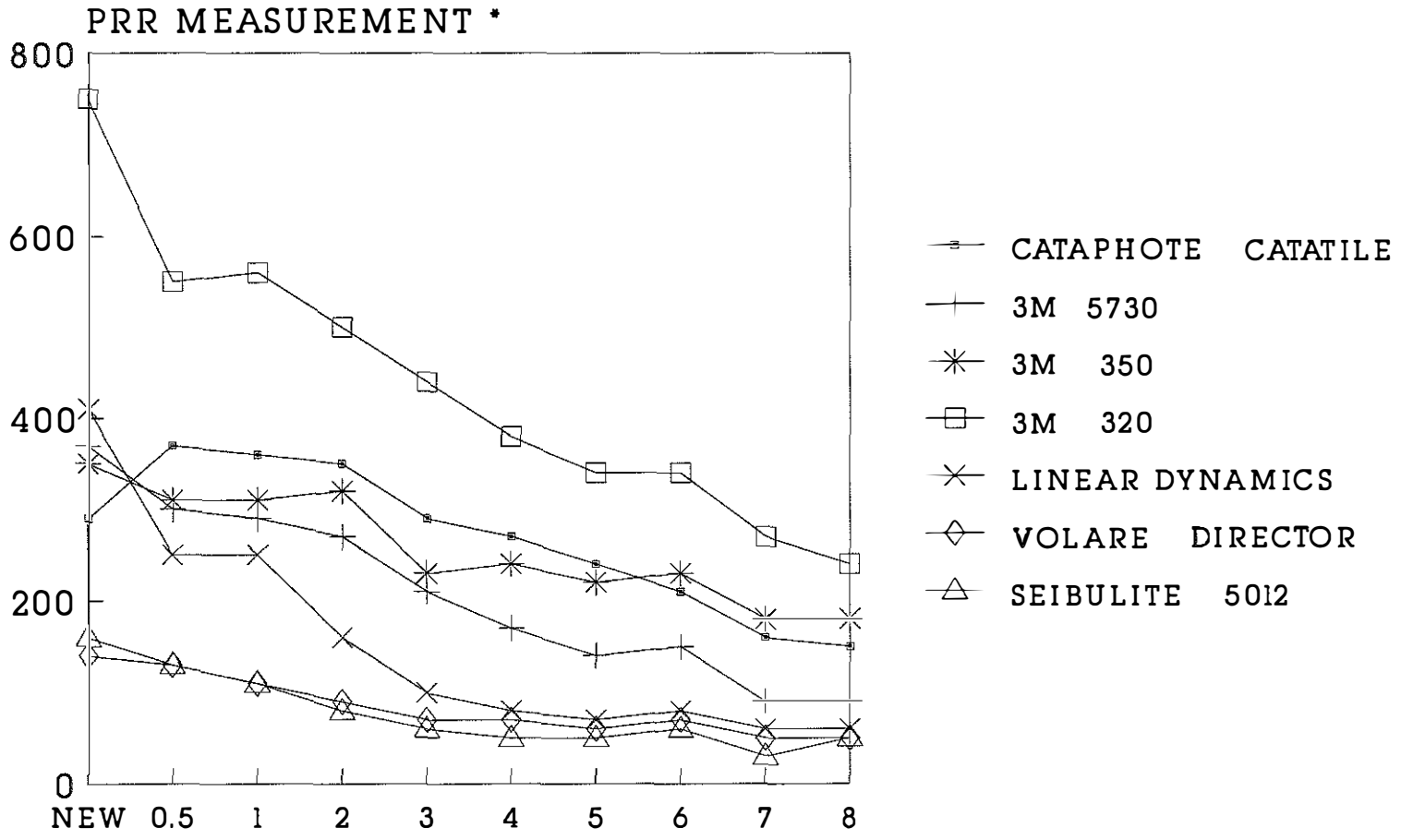


Figure 5. PRR Measurements for White Permanent Tape.

PRR MEASUREMENTS FOR PERMANENT TAPE
YELLOW



* Millicandelas/square foot/footcandles

Figure 6. PRR Measurements for Yellow Permanent Tape.